The role of the laboratory in disease surveillance

Bradford A. Kay¹

دور المختبر في ترصد الأمراض

برادفورد أ. كاي

خلاصة المعلومات التي تعطيها المختبرات لها أهمية حاسمة في برامج ترصد الأمراض ومكافحتها . فقبل وقوع الفاشية يمكن اكتشاف الحالات في وقت مبكر عن طريق الترصد المدعوم بنتائج المختبر . وأثناء حدوث الفاشية ينبغي التحقق مخبريا من عينات من الحالات من أجل تقييم ما يطرأ على العامل المسبب من تغيرات ، ولتوجيه ما يلزم اتخاذه من قرارات حول تخصيص الموارد . ويتاح الدعم من قبل مختبرات ذات قدرات متباينة . فالمختبرات الميدانية تفيد في المناطق ذات الموارد القليلة أو المنعدمة . وعادة ما تجري اختبارات أكثر اكتمالا في المختبرات الإقليمية . أما المختبرات المرجعية الدولية فقد تتعرف على الكائنات الممرضة النادرة أو الخطيرة ، وتشخص المكروبات المكتشفة حديثا ، وتقدم الكواشف التشخيصية غير الشائعة . ويتعين أن تكون معلومات المختبرات دقيقة ، ومتاحة في الوقت المناسب ، وخاصة لإجراءات ضمان الجودة .

ABSTRACT Laboratory information is critical for disease surveillance and control programmes. Before an outbreak, laboratory-supported surveillance allows early detection of cases. During an outbreak a sample of cases should be laboratory confirmed to assess changes in the etiological agent and to guide decisions about the allocation of resources. Support is provided by laboratories of differing capabilities. Field laboratories are useful in areas where resources are limited or nonexistent. More complete testing is usually done in regional laboratories. International reference laboratories may identify rare or dangerous pathogens, identify newly described organisms; and provide uncommon diagnostic reagents. Laboratory information must be accurate, timely and subjected to quality assurance procedures.

Le rôle du laboratoire dans la surveillance des maladies

RESUME L'information que fournit le laboratoire est d'une importance capitale pour les programmes de surveillance des maladies et de lutte contre celles-ci. Avant une flambée épidémique, la surveillance effectuée à l'aide du laboratoire permet de dépister les cas à un stade précoce. Lors d'une flambée épidémique, un échantillon de cas devrait être confirmé au laboratoire afin de déterminer les mutations de l'agent étiologique et guider les décisions concernant l'allocation des ressources. L'appui est fourni par des laboratoires possédant différentes capacités. Les laboratoires mobiles sont utiles dans les zones où les ressources sont limitées ou inexistantes. Les laboratoires régionaux effectuent généralement des examens plus complets. Les laboratoires internationaux de référence peuvent identifier des agents pathogènes rares ou dangereux, des organismes nouvellement décrits et fournir des réactifs diagnostiques peu courants. L'information fournie par le laboratoire doit être exacte, opportune et soumise aux procédures d'assurance de la qualité.

¹ United States Naval Medical Research Unit No. 2 (NAMRU), Cairo 11517, Egypt.

Introduction

Infectious diseases constitute the major cause of death worldwide and will not be conquered during our lifetimes.

*Report on Emerging Diseases, 1992
US Institute of Medicine*

Accurate and timely laboratory information has become the foundation upon which current disease treatment, prevention and control programmes are based. This reliance on laboratory-derived information has, for the past 100 years, paralleled the development of modern medicine and public health.

In 1992 the Institute of Medicine, an organization of the US National Academy of Sciences, issued a landmark report documenting the continuing global rise in infectious diseases [1]. According to the report, developed and developing economies are similarly at risk, and the welfare of every nation is threatened by the lack of infrastructure for disease detection, control and prevention. In response to these threats strategies have been proposed by the Centers for Disease Control and Prevention in Atlanta [2] and the World Health Organiza-

tion (WHO) [3]. In the WHO plan, five goals have been identified for combating emerging and re-emerging infectious diseases (Table 1). Strengthened disease surveillance and enhanced international laboratory infrastructure lead these recommendations, and some aspect of laboratory practice is a component of each of the WHO goals. In order to accomplish these goals, WHO recommended that collaborating laboratories form local and regional "partnerships" and "horizontal laboratory networks". In concept, these voluntary cooperative networks will share information and report unusual patterns of human and zoonotic disease. In order to effectively perform these tasks, collaborating laboratories will require ongoing logistical, financial and scientific support. This support must come in many forms and will include technology transfer, the availability of critical reagents and supplies, enhanced communications capabilities, ongoing quality control/quality assurance activities and the means for retaining competent, trained personnel who possess rare expertise or unique diagnostic capabilities (Table 2).

Table 1 WHO goals for control of emerging infectious diseases

1. Strengthen global surveillance capabilities
2. Strengthen laboratory infrastructure and capacity
3. Create an applied research programme
4. Strengthen disease prevention and control capacity
5. Improve communications to target groups

Source: Report of the WHO meeting on emerging infectious diseases, Geneva, 25-26 April 1994. Geneva, World Health Organization, 1994 (WHO/CDS/BVI/94.2)

Table 2 Components of the WHO plan to strengthen laboratory infrastructure

Ensure availability of:

- diagnostic reagents (common and rare)
- equipment
- training of laboratory personnel
- rare expertise or capabilities
- quality control programmes
- quality assurance practices
- effective data management and analysis
- regular communications
- technology transfer or exchange

Laboratory support: a key to disease surveillance

Accurate laboratory-based information is a critical component of disease surveillance and is among the highest goals of disease control programmes. Pathogen-specific surveillance information, based on factors such as geographic range, vectors, antibiotic resistance and biotype/serotype of the etiologic agent, is critical for predicting outbreaks and for differentiating background events from true outbreaks. Early detection of disease outbreaks with confirmation of etiology allows the institution of proper treatment, control and prevention practices. Likewise, during a disease outbreak a sample of cases should be laboratory confirmed in order to monitor the characteristics of the epidemic strain of the organism. Significant changes in key phenotypic or genotypic characteristics (antibiotic resistances, serotype, biotype, antigenic shifts, etc.) may warrant changes in treatment or control practices.

A team effort

Laboratories are composed of numerous diverse and complex elements that go beyond the issues of science and medicine. Of these, the single most important asset is the knowledge and expertise of the laboratory employee. Highly trained, motivated employees with access to adequate resources are able to consistently produce high quality results. However, as in all systems, the quality of the output of a laboratory is directly related to the quality of the input and the quality of the process itself. Knowledge, training and teamwork are required to obtain adequate specimens for testing and to ensure correct processing, handling, storage, analysis and reporting. Each step in the process is critical to the overall accuracy of the result and each step must be competently performed and coordinated with subsequent steps.

Laboratory facilities and capabilities

Adequate epidemiological support can often be provided by laboratory facilities of differing levels of sophistication and capabilities. Field laboratories, either portable, mobile or fixed, can provide screening tests and simple diagnostic procedures in areas where more extensive resources are limited or nonexistent. Field facilities, however, may be limited to collection and processing of specimens or the performance of simple, rapid diagnostic procedures that do not require significant environmental controls, containment capabilities or support facilities. Field laboratories, however, require significant logistical support and are best suited to providing limited services for brief periods of time.

Larger laboratories, such as those found at the district, regional and national levels require significant infrastructure and support. These larger facilities, however, are often the only ones with the resources to perform complex or lengthy testing procedures, such as viral cultures and molecular biological assays. These facilities often operate in concert with smaller facilities and field laboratories in order to expand the availability of regional diagnostic capabilities. Tests offered may include the isolation, identification and characterization of the spectrum of pathogenic microorganisms.

International reference laboratories, such as WHO collaborating centres, are often asked to confirm the identification of rarely encountered organisms as well as to identify extremely dangerous pathogens. These laboratories may also be able to identify newly described pathogens and may represent the only source for infrequently used diagnostic reagents and materials. It is important that these unique facilities be empowered to maintain not only their exper-

tise, but also supplies of reagents for which there may be no commercial supplier.

Laboratory modules

In a recent publication by the WHO Regional Office for the Eastern Mediterranean (EMRO) laboratory support components and diagnostic tests for peripheral and field laboratories were grouped together into modules in order to simplify planning for laboratory needs [4]. The modules were designed around a specific laboratory need (power, for example), medical procedure (phlebotomy) or group of related diagnostic tests (enteric stool screen). The EMRO publication presents several additional modules and their components. The module concept can be useful in developing plans for providing the minimal requirements for field laboratories responding to disease outbreaks or other emergency situations in which logistical considerations must be rapidly and efficiently made.

Laboratory-based communications

Rapid and effective communication of laboratory information is an essential component of infectious disease surveillance. Modern communications and computer technology offer the opportunity for rapidly compiling and disseminating information. Strengthening the communications capabilities of laboratories is of great importance and is a component of the WHO plan to strengthen laboratory infrastructure worldwide. Numerous innovative means of transmitting laboratory information have been recently developed. A sampling of these is presented in Table 3. Nearly all disease reporting systems are now available electronically. Using these systems allows not only the rapid dissemination of information but also the creation of global data sets of infectious disease information. As these data are compiled and analysed they should provide a

Table 3 Examples of laboratory-based communications

Communications networks

WHONET	WHO-sponsored reporting network for antimicrobial resistance
ProMED	Internet program to monitor emerging diseases
Salm-Net	European salmonella network
Legionnaire's Network	Legionnaire's disease network

Software

LITS/PHLIS	CDC-developed software for compiling and managing laboratory and epidemiological data
------------	---

Publications and bulletins

<i>Weekly epidemiological record</i>	World Health Organization
<i>Morbidity and mortality weekly report</i>	US Public Health Service

clearer understanding of the dynamics of all infectious diseases.

Quality assurance and quality control

Effective quality control and quality assurance programmes help to ensure the accuracy of laboratory results and heighten their utility in programmes for disease control. Good laboratory practices require that appropriate quality control and quality assurance procedures be regularly used at all levels. The quest for maximum efficiency and effectiveness coupled with a reduction in errors and reduction in risk to the worker are essential components of quality assurance and laboratory management. Quality assurance should include internal quality

Table 4 Laboratory elements requiring quality control and quality assurance procedures

Appropriateness of test

Patient and specimen preparation and sampling
Specimen identification and documentation
Preservation, handling, transport of specimens
Storage of specimens
Reagent integrity
Equipment reliability and calibration
Technician knowledge
Test performance, reference standards
Data management, record keeping, analysis
Reporting timing and accuracy

controls and external quality assessment. A comprehensive programme of quality assurance should include the elements of test selection, patient and sample preparation, documentation, transport, handling and storage, sample analysis, reports, and analysis of data [5]. Laboratory elements to be considered when evaluating the quality of laboratory activities and test results are presented in Table 4.

In summary, the modern public health or diagnostic laboratory is a key component of surveillance and disease control programmes. Effective laboratory operations are the result of a team effort. Laboratories come in many sizes, varieties and capabilities and should be selected based on the proper use of their individual capabilities. Effective communications, as in all human endeavours, is a key to success. Means should be sought to continually improve communicating laboratory information. Finally, quality control and quality assurance must be incorporated into all aspects of laboratory management and practice for continued excellence.

Acknowledgement

This work was supported by the Naval Medical Research and Development Command, Bethesda, MD, Work Unit No. 00101.EAX.3424. The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or as reflecting the views of the US Navy Department, US Department of Defense, the US Government or the Egyptian Ministry of Health.

References

1. Lederberg J; Shope R, Oaks S, eds. *Emerging infections: microbial threats to health in the United States*. Washington, DC, Institute of Medicine, National Academy of Sciences, 1992.
2. *Addressing emerging infectious disease threats: a prevention strategy for the United States*. Atlanta, Georgia. Centers for Disease Control and Prevention, US Public Health Service, 1994.
3. *Report of the WHO meeting on emerging infectious diseases, Geneva, 25-26 April, 1994*. Geneva, World Health Organization, 1994 (WHO/CDS/BVI/94.2).
4. Warren J et al., eds. *Health laboratory facilities in emergency and disaster situations*. Alexandria, Egypt, World Health Organization Regional Office for the Eastern Mediterranean, 1994 (document WHO/EMRO No. 6).
5. El-Nageh M et al., eds. *Basics of quality assurance for intermediate and peripheral laboratories*. Alexandria, Egypt, World Health Organization Regional Office for the Eastern Mediterranean, 1992.